

EXHIBIT B

CERTIFICATION OF TRANSLATION

I, LEE, Young Ju, an employee of Y.P. LEE, MOCK & PARTNERS of The Cheonghwa Bldg., 1571-18 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare under penalty of perjury that I understand the Korean language and the English language; that I am fully capable of translating from Korean to English and vice versa; and that, to the best of my knowledge and belief, the statements in the English language in the attached translation of Notification of Invention (Superconducting Magnesium Diboride Thin Film and Method and Apparatus for Fabricating the Same), consisting of 6 pages, have the same meanings as the statements in the Korean language in the original document, a copy of which I have examined.

Signed this 30th day of September, 2005

youngju Lee

SPECIFICATION

1. Title of the Invention

Method of Forming Superconducting Magnesium Diboride Thin film

5

2. Brief Description of the Drawings

FIG. 1 is a schematic view illustrating a laser deposition apparatus used for step 1 of the present invention.

FIG. 2 is a schematic view illustrating a thermal process apparatus used for step 2 of the present invention.

10

<Description of Reference Numerals for Main Components of Drawings>

1: direction in which laser beam is radiated

2: support plate for substrate

15

3: high-vacuum container for thin film growth

4: substrate

5: boron evaporation toward substrate

6: target and support plate for target

7: section of horizontal type electric furnace

8: quartz tube

9: tantalum tube

20

10: boron thin film

11: sapphire substrate

12: magnesium

3. Detailed Description of the Invention

The present invention relates to a method of forming a magnesium diboride (MgB₂) thin film.

25

Recently, a research report on MgB₂ in *Nature* 410, p.63, March 1, 2001 by Nagamatsu *et al.* discloses superconducting MgB₂ having a transition temperature as high as 39 K, compared to the transition temperature of 23 K for conventional superconducting metals. MgB₂ also has high current transporting capability due to higher conduction-electron density. Thus, it is highly probable that almost all existing conventional superconducting materials will be replaced with the MgB₂ superconductor. Such highly probable applicability of the superconducting MgB₂ has boosted recent research on superconducting MgB₂ worldwide. As an example, P.C. Canfield *et al.* at the Iowa State Univ. (US) developed superconducting wires for

30

practical uses (*Phys. Rev., Lett.* (March, 2001)). By way of more illustrative example, it is known that the embargo on the export of magnesium and boron essential for preparation of MgB_2 superconductors was recently placed in America, Japan, etc. to acquire priority to the study and commercialization of the MgB_2 superconductors. Meanwhile, processing of superconducting MgB_2 into a thin film is essential for its application in a variety of electronic devices, and thus has been globally studied by many research groups. However, there have not yet been any reports of superconducting MgB_2 in the form of thin film with satisfactory effects. That is, a superconducting MgB_2 thin film of the present invention is the first invention in the world. Up until now, no patent applications related to the present invention have been filed. A superconducting MgB_2 thin film formed according to the present invention can be used in precision medical diagnosis equipment using superconducting quantum interface devices (SQUIDs) capable of sensing weak magnetic fields, microwave communications equipment used for satellite communications, and Josephson devices. Computer systems with 100 times greater computing speed can be implemented with the superconducting MgB_2 thin film.

A method of forming a MgB_2 thin film according to the present invention roughly involves two steps: step 1 is to deposit amorphous boron which is a precursor of MgB_2 on a substrate using a physical thin film deposition apparatus (laser deposition apparatus, sputtering deposition apparatus, electron beam deposition apparatus) to form a boron thin film and step 2 is to form a superconducting MgB_2 thin film through reaction of the boron thin film with magnesium.

A. Step 1 (boron thin film formation)

To deposit a boron thin film by a physical thin film deposition method, a target is needed. For this, a coin-like target for use in the deposition of the boron thin film was prepared by stuffing a cylindrical mold (having a diameter of 25.4 mm) with appropriate amount of small-sized boron powders and applying pressure on the order of 6-10 tons. The target is fixed to a support plate for the target shown in FIG. 1 and irradiated with an excimer laser beam. As a result, boron is evaporated from the target and forms a boron thin film on the substrate fixed to the top of the support plate for the substrate. The boron deposition is carried out under the conditions of a

laser pulse frequency of about 8 Hz and a laser beam energy of 550 mJ. At this time, since boron's vaporizing temperature is very high, a laser beam energy density increased to 20-30 J/cm² by a lens is used. When boron deposition is continued for about 3 hours under the above conditions, a boron thin film having a thickness of about 0.5 μ m and a mirror-like glossy surface is obtained. The substrate on which the boron thin film is formed may be a monocrystalline sapphire (Al₂O₃, plane <1102>) substrate or a monocrystalline strontium titanate (SrTiO₃, plane <001>) substrate. A monocrystalline sapphire substrate is more preferable for formation of a MgB₂ thin film.

B. Step 2 (thermal process)

In Step 2, a superconducting MgB₂ thin film is formed by diffusing magnesium into the boron thin film through a thermal process to grow MgB₂ crystal having uniform orientation. Magnesium is easy to oxidize and has a melting temperature of 650°C and a vaporizing temperature of 1107°C, which are much lower than the melting point of 2100°C and vaporizing temperature of 4000°C of boron. Magnesium needs high-pressure reaction conditions due to its poor reactivity at atmospheric pressure. Thus, the present inventors developed a special thermal process enabling prevention of magnesium oxidation and high-pressure reaction and thus successfully manufactured a MgB₂ thin film.

An apparatus for such a special thermal process is illustrated in FIG. 2 and its detailed description will be given below. To grow MgB₂ crystal through reaction of the boron thin film with magnesium, the boron thin film and the magnesium source must be heated at a temperature of 600-1000°C in an electric furnace. However, since the magnesium source may form magnesium oxide through reaction with oxygen in air, it is necessary to grow MgB₂ crystal in oxygen-free environment. Tantalum, tungsten, etc. are known as a material incapable of causing chemical reaction with the magnesium source. In the present invention, to prevent the boron thin film and the magnesium source from oxidizing, a tantalum tube with good ductility and weldability is used as shown in FIG. 2. Furthermore, to prevent oxidation of tantalum in contact with air, the tantalum tube is protected by a quartz tube. Thus, in the present invention, the boron thin film and the magnesium source are double-sealed with the above-described thermal treatment apparatus. Meanwhile, when a MgB₂ thin film is formed at a high temperature, it is difficult to

obtain a high-quality thin film due to chemical reaction of the MgB_2 thin film with the substrate. In view of this problem, the thermal process is carried out in a short time. That is, in the present invention, an electric furnace using a horizontal quartz tube is used. Prior to placing a sample into the electric furnace, the electric furnace is raised to 600-1000°C. Then, the sample is moved to a uniform-temperature center region of the electric furnace within 30 minutes, heated at a temperature of 600-1000°C within about 2 hours, immediately drawn out of the electric furnace, and cooled within 1 hour. A result of an X-ray diffraction test on a MgB_2 thin film obtained by the above-described method shows that the resultant MgB_2 thin film is a good thin film having the c-axial orientation. The MgB_2 thin film formed by the method has a superconducting critical temperature of 39 K and a critical current density of 8,000,000 A/cm² which satisfy the superconductor requirements necessary for commercial applications. The superconducting critical temperature of the MgB_2 thin film is the same as that of superconducting MgB_2 wires. The critical current density of the MgB_2 thin film sets the highest record of 20 times greater current transporting capability than superconducting MgB_2 wires. These results reveal that the MgB_2 thin film of the present invention is the most commercially valuable. Thus, mass production of the present invention by technical reinforcement enables sufficient industrialization.

What is claimed is:

1. A method comprising step 1 of depositing a boron thin film using pulsed laser deposition, sputtering deposition, electron beam evaporation, metal
5 organic chemical vapor deposition (MOCVD), or chemical vapor deposition.

2. A method comprising step 2 of diffusing a magnesium source into an amorphous boron thin film.

10 3. The method of claim 2, wherein a tantalum tube that does not react with the magnesium source is used by arc welding under an inert gas atmosphere.

4. The method of claim 2, wherein both ends of a quartz tube is sealed to prevent oxidation of tantalum.

15 5. The method of claim 2, wherein an electric furnace is heated to 600-1000°C, a sample is placed in the electric furnace within 30 minutes, rapidly heated at the temperature of 600-1000°C within 2 hours, immediately drawn out of the electric furnace, and cooled within 1 hour.

Abstract of the Disclosure

The present invention relates to a novel method of forming a superconducting MgB_2 thin film which was recently invented (January 10, 2001). The method of the present invention has very high applicability in electronic devices employing superconducting thin films. The method of forming the superconducting MgB_2 thin film comprises depositing an amorphous boron thin film using a high-vacuum pulsed laser deposition apparatus and rapidly heating the boron thin film in an electric furnace. To prevent a sample from oxidizing or contaminating during the thermal process, a tantalum tube and a quartz tube are used. Therefore, a high-quality MgB_2 thin film can be formed. For industrialization of the MgB_2 thin film, mass production is essential. Thus, there is room for improvement in technology for transformation into mass-production system.

The MgB_2 thin film of the present invention is the first invention in the world and there is no doubt that the MgB_2 thin film can be produced on an industrial scale. The MgB_2 thin film can be used in precision medical diagnosis equipment using superconducting quantum interface devices (SQUIDs) capable of sensing weak magnetic fields, microwave communications equipment used for satellite communications, and Josephson devices. Computer systems with 100 times greater computing speed can be implemented with the superconducting MgB_2 thin film. Therefore, it is thought that the economic value of the MgB_2 thin film would be considerable.

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.